Real-time and retrospective forcing in the North American Land Data Assimilation System (NLDAS) project

Brian A. Cosgrove,[1,2] Dag Lohmann,[3] Kenneth E. Mitchell,[3] Paul R. Houser,[1] Eric F. Wood,[4] John C. Schaake,[5] Alan Robock,[6] Curtis Marshall,[7] Justin Sheffield,[4] Qingyun Duan,[5] Lifeng Luo,[6,8] R. Wayne Higgins,[9] Rachel T. Pinker,[10] J. Dan Tarpley,[11] and Jesse Meng[3]

Received 31 October 2002; revised 27 February 2003; accepted 31 March 2003; published 31 October 2003.

[1] The accuracy of forcing data greatly impacts the ability of land surface models (LSMs) to produce realistic simulations of land surface processes. With this in mind, the multi-institutional North American Land Data Assimilation System (NLDAS) project has produced retrospective (1996–2002) and real-time (1999–present) data sets to support its LSM modeling activities. Featuring 0.125° spatial resolution, hourly temporal resolution, nine primary forcing fields, and six secondary validation/model development fields, each data set is based on a backbone of Eta Data Assimilation System/Eta data and is supplemented with observation-based precipitation and radiation data. Hourly observation-based precipitation data are derived from a combination of daily National Center for Environmental Prediction Climate Prediction Center (CPC) gauge-based precipitation analyses and hourly National Weather Service Doppler radar-based (WSR-88D) precipitation analyses, wherein the hourly radar-based analyses are used to temporally disaggregate the daily CPC analyses. NLDAS observation-based shortwave values are derived from Geostationary Operational Environmental Satellite radiation data processed at the University of Maryland and at the National Environmental Satellite Data and Information Service. Extensive quality control and validation efforts have been conducted on the NLDAS forcing data sets, and favorable comparisons have taken place with Oklahoma Mesonet, Atmospheric Radiation Measurement Program/cloud and radiation test bed, and Surface Radiation observation data. The real-time forcing data set is constantly evolving to make use of the latest advances in forcing-related data sets, and all of the real-time and retrospective data are available online at http://ldas.gsfc.nasa.gov for visualization and downloading in both full and subset forms. *INDEX TERMS:* 1866 Hydrology: Soil moisture; 1899 Hydrology: General or miscellaneous; 3322 Meteorology and Atmospheric Dynamics: Land/atmosphere interactions; 3337 Meteorology and Atmospheric Dynamics: Numerical modeling and data assimilation; *KEYWORDS:* NLDAS, North American Land Data Assimilation System, forcing data, LSM, land surface modeling, LDAS

Citation: Cosgrove, B. A., et al., Real-time and retrospective forcing in the North American Land Data Assimilation System (NLDAS) project, *J. Geophys. Res.*, *108*(D22), 8842, doi:10.1029/2002JD003118, 2003.

1. Introduction

[2] An essential component of land surface modeling studies is the forcing data used to drive the participating land surface models (LSMs). No matter how sophisticated

[1]Hydrological Sciences Branch, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.
[2]Also at General Sciences Operation, Science Applications International Corporation, Beltsville, Maryland, USA.
[3]Environmental Modeling Center, National Centers for Environmental Prediction, National Oceanic and Atmospheric Administration, Camp Springs, Maryland, USA.
[4]Department of Civil and Environmental Engineering, Princeton University, Princeton, New Jersey, USA.
[5]Office of Hydrologic Development, National Weather Service, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, USA.
[6]Department of Environmental Sciences, Rutgers University, New Brunswick, New Jersey, USA.
[7]Department of Atmospheric Sciences, Colorado State University, Fort Collins, Colorado, USA.
[8]Now at Department of Civil and Environmental Engineering, Princeton University, Princeton, New Jersey, USA.
[9]Environmental Modeling Center, National Centers for Environmental Prediction, National Oceanic and Atmospheric Administration, Camp Springs, Maryland, USA.
[10]Department of Meteorology, University of Maryland, College Park, Maryland, USA.
[11]Office of Research, National Environmental Satellite Data and Information Service, National Oceanic and Atmospheric Administration, Camp Springs, Maryland, USA.

0148-0227/03/2002JD003118$09.00

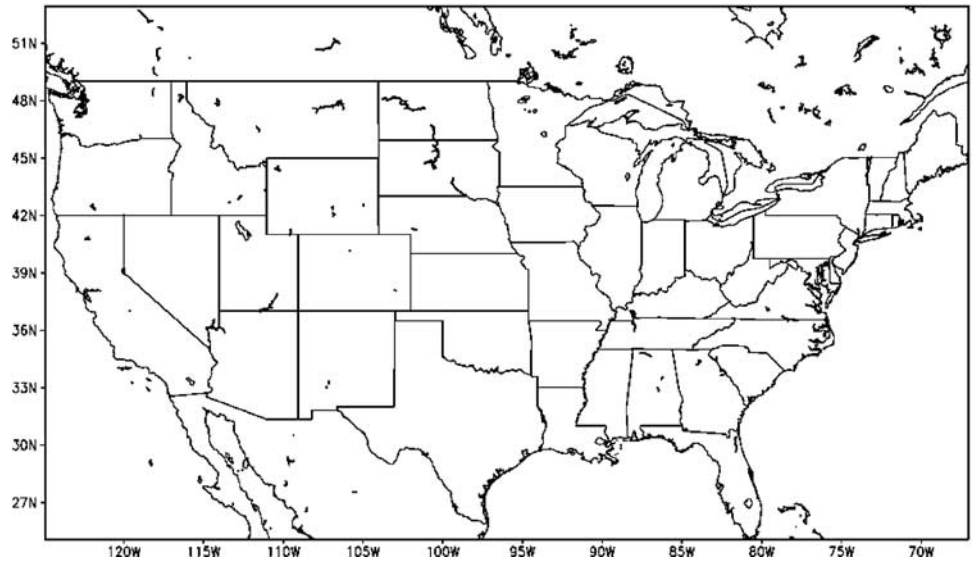

Figure 1. NLDAS 0.125° domain, extending from northern Mexico to southern Canada.

their depiction of land surface processes, or how accurate their boundary and initial conditions are, such models will not produce realistic results if the forcing data is not accurate. LSMs depend upon such externally supplied quantities as precipitation, radiation, temperature, wind, humidity and pressure to forecast land surface states, and errors in any of these quantities can greatly impact simulations of soil moisture, runoff, snow pack and latent and sensible heat fluxes. Each of these forcing quantities can be supplied by atmospheric Numerical Weather Prediction (NWP) models; however, such models are subject to internal model biases and errors in parameterizations that may negatively impact the quality of their output. As such, a more robust approach is to make use of as much observation-based forcing data as possible. This approach is especially important for offline Land Data Assimilation Systems (LDAS). Such systems seek to produce accurate simulations of land surface states by making use of observational data and isolating land surface modeling systems from the biases inherent in internally cycled NWP modeling systems.

[3] With this in mind, the North American Land Data Assimilation System (NLDAS) project [*Mitchell et al.*, 1999; K. E. Mitchell et al., The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system, submitted to *Journal of Geophysical Research*, 2003] has sought to construct quality controlled, spatially and temporally consistent, real-time and retrospective forcing data sets from the best available observations and model output to support its multi-LSM modeling activities. NLDAS is a multi-institution partnership, which involves participants from the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction Environmental Modeling Center (NCEP/EMC), National Aeronautics and Space Administration Goddard Space Flight Center (NASA GSFC), NOAA National Weather Service Office of Hydrologic Development (NWS/OHD), NOAA National Environmental Satellite Data and Information Service Office of Research and Applications (NESDIS/ORA), Princeton University, Rutgers University, the University of Washington and the University of Maryland.

5. Conclusion

[25] Land surface models depend heavily upon accurate forcing data in order to produce realistic simulations of land surface processes. With this in mind, the NLDAS project has produced real-time and retrospective 0.125°, hourly forcing data sets. Supporting the real-time and retrospective modeling efforts of the project, each data set uses EDAS/Eta model output as a data backbone, and incorporates observation-based radiation and precipitation data when available. The incorporation of these two observation-based variables is of great importance, for though they exert a large influence on surface processes, NWP models, such as the Eta model, find them particularly difficult to represent accurately. Each data set has been quality controlled based on ALMA forcing data standards, and each is available from the LDAS web site in either full or subset form through FTP and a Real-Time Image Generator. Along with its constituent, raw data sets, the retrospective data set extends from 1996 to 2002, and will be lengthened to cover 2003 in upcoming months. Overlapping a portion of this coverage, the real-time forcing data set extends from 1999 to the present. Updated once per day, it is dynamic in nature, and will incorporate advances in forcing-related data sets as they occur. Improvements may include increases in the backbone EDAS/Eta data resolution, advances in the treatment of precipitation interpolation, and increases in the spatial extent and resolution of GOES-based data, and will maximize the accuracy and utility of the NLDAS forcing data.